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Full Length Research Paper

Influence of salinity stress on photosynthesis and chlorophyll content in date palm (*Phoenix dactylifera* L.) cultivars

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Date palm (*Phoenix dactylifera* L.) is cultivated in the Kingdom of Saudi since pre-historic times and is the most important fruit crop of the Kingdom. High soil salinity is a major abiotic stress that is impacting on the productivity of date palm in the Arabian Peninsula. Trials conducted at the National Date Palm Research Centre, Al Hassa, Saudi Arabia to determine the effect of NaCl induced salinity on photosynthesis and chlorophyll in the three date palm cultivars *viz*. Khalas, Madjool and Barhy revealed that increasing soil salinity levels (0, 50, 100, 200 and 400 mM NaCl) resulted in progressive decrease of K^+, K^+/Na^+ ratio and N content, along with increase in Na^+ levels in all the three tested cultivars. Increasing salinity levels also decreased the net photosynthesis and chlorophyll levels in these cultivars. However, Saudi Arabia's premier date cultivar 'Khalas' was able to withstand increasing salinity levels as compared to Majdol and Barhi.

Key words: Salinity, *Phoenix dactylifera* L., photosynthesis, chlorophyll content.

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) is a major fruit crop in the Arabian Peninsula where it is closely associated with the life of the people since pre-historic times. In the Kingdom of Saudi Arabia (KSA) date palm covers approximately 72% of the total area under permanent crops. Date palm is a multipurpose tree that provides food, shelter and timber products. The date fruit is a good source of food providing, fiber, carbohydrates, minerals and vitamins besides having anti-mutagenic and anti-carcinogenic properties (Baloch et al., 2006; Al-Farsi et al., 2005; Ishurd and Kennedy, 2005; Vayalill, 2002; Mohamed, 2000). More than 400 different date palm cultivars are reported to exist in Saudi Arabia (Anonymous, 2006). The Kingdom of Saudi Arabia with an estimated 25 million date palms produces nearly a million tones of dates annually with a good potential for exporting the surplus produce. (Al-Abdoulhadi et al., 2011; Al-Abbad, 2011; Al- Darwish and Abdallah, 2011). Soil salinity is a major abiotic stress adversely impacting date palm in the Arabian Peninsula.

Date palm exhibits a high degree of tolerance to salinity (Zaid and de Wet, 2002); however growth and productivity can be greatly reduced (Erskine et al., 2004). Seedlings are more sensitive to salinity than mature plants as salt tolerance in plants is generally age dependant. We studied the impact of salinity on photosynthesis and chlorophyll content in offshoots of three date palm cultivars besides quantifying K^+, Na^+ and N levels in mature leaves under different treatments in the tested cultivars.

MATERIALS AND METHODS

The experiments were carried out at the experimental site of the National Date Palm Research Center at Al Hassa, Saudi Arabia. Al-Hassa (25°19' 60"N latitude and 49°37' 60" E longitude) is the

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largest date palm oasis of Saudi Arabia situated in the Eastern Province of the Kingdom having an estimated three million date palms.

Date palm cultivars

Three-year-old offshoots of Khalas, Madjool and Barhy date palm cultivars were used. The test cultivars for this study were selected based on the local, regional and international importance. While Khalas is the most popular date palm cultivar in the Eastern province of Saudi Arabia where Al-Hassa is located, the cultivar Madjool is an internationally acclaimed date cultivar of North Africa while the date palm cultivar Barhi has high regional preference among farmers of the Gulf countries in the Middle East.

The study pertains to the nonbearing stage of date palm cultivars (young offshoots), since adult trees are difficult to partition for detailed nutrient analysis and biomass production. Furthermore, many studies have shown the close relation of such studies between effects on nonbearing (offshoots/seedlings) and bearing stages (adult trees) of fruit crops (Marschner, 1997; Sykes, 1992).

Salinity treatments and salinity culture system

The growth medium was salinized with 0, 50, 100, 200 and 400 mM NaCl as the main source of salinity for the experiment. These concentrations represent low (0 and 50 mM NaCl), medium(100 mM NaCl), high (200 mM NaCl) and excessively high (400 mM NaCl) salinity conditions.

The offshoots were grown in 30-litre pots filled with quartz sand (particle size 0.7-2.0 mm, field capacity 17.7 wt%). Natural soil of date palm stands was not used since it includes nutrients that would interfere with the treatments. However, defined amounts of nutrients applied as compound NPK (N18%- P18%- K5%) fertilizers were provided as 10 g NPK to each off shoot twice a year during the course of the experiment.

Gas exchange

Gas exchange measurements were taken for the same leaf categories as described before. Each set of data (replicate) was a mean of two measurements taken from two different leaves from the same plant, which was determined at three-monthly intervals during the course of the experiment.

The gas exchange rates (P_n) were measured using a portable photosynthesis meter (CI-301 PS, CID, Inc., USA).

Chlorophyll content

Chlorophyll (a, b and total) was determined in intact leaves using a SPAD chlorophyll meter. An alternative method is the use of a portable Chlorophyll Meter (SPAD-502) unit of Minolta Camera Company. The principle of measurement of SPAD-502 is based on the difference in light attenuation at 650 and 940 nm. Operationally, measurement of leaf colour is accomplished by inserting a leaf blade into the head of the SPAD-502 Chlorophyll Meter.

Analytical procedures for K^+ Na^+ and N

Chemical procedures for determination of K^+ and Na^+ were analyzed with flame emission according to AOAC (1989). Total nitrogen was determined using an automated semi-micro Kjeldahl apparatus.

Statistical analysis

A fully randomized block design with factorial combinations of three date palm cultivars and five NaCl levels replicated three times were used to conduct the experiment. Experimental data on all variables was subjected to analysis of variance (ANOVA) procedures using the SAS program (SAS Institute, Inc. 1985). Mean separation was calculated by Duncan Multiple Range Test (Gomez and Gomez, 1984). Experimental results are presented and discussed below. Throughout, p=0.05 was used to define statistical significance.

RESULTS

Results presented in Figure 1 reveal that photosynthesis reduced significantly by 2.8, 21, 29 and 54% with increasing salt level from 50 to 100, 200 and 400 mM NaCl, respectively. The cultivar Khalas recorded the least reduction in photosynthesis as compared to the cultivars Madjool and Barhy at 400 mM NaCl (45, 59 and 59%) It can therefore be inferred that Khalas is more salt tolerant than Madjool and Barhy and is more suitable for cultivation where salinity is a problem. In the three tested cultivars; K^+ levels decreased with increase in salinity while Na^+ increased with increasing levels of salinity. The K^+/Na^+ ratio followed the same trend as K^+ with increase in the salinity (Figures 2, 3, and 4).

N levels (Figure 5) and chlorophyll content (Table 1) also decreased with increasing salinity. Results presented in Table 1 reveal that there was no significant difference in the chlorophyll content at 0 and 50 mmol/l. However, increasing salinity levels more than 50 mmol/l resulted in decrease of chlorophyll. At salinity higher than 50 mmol/l the cultivar Khalas recorded significantly higher chlorophyll content than the other tested cultivars. Pronounced reduction in N content was only noticed at very high salinity (400 mmol/l).

DISCUSSION

Potassium is an important component for photosynthesis in higher plants. The ability of plants to tolerate salinity depends on the K^+ status in leaves (Maathuis and Amtmann, 1999). Reports from Egypt are in agreement with our findings where selective uptake of K^+ by date palm seedlings increased with increasing salinity (Hassan and El-Samnoudi, 1998). In the present study the decrease in K^+ / Na^+ ratio with increasing salinity can be attributed to increase in Na^+ at increasing salinity levels as reported by Youssef and Awad (2008) from the United Arab Emirates.

CONCLUSION

High soil salinity is a major abiotic stress impacting the productivity of date palm in the Arabian Peninsula. In the process of photosynthesis, plants assimilate CO_2 from

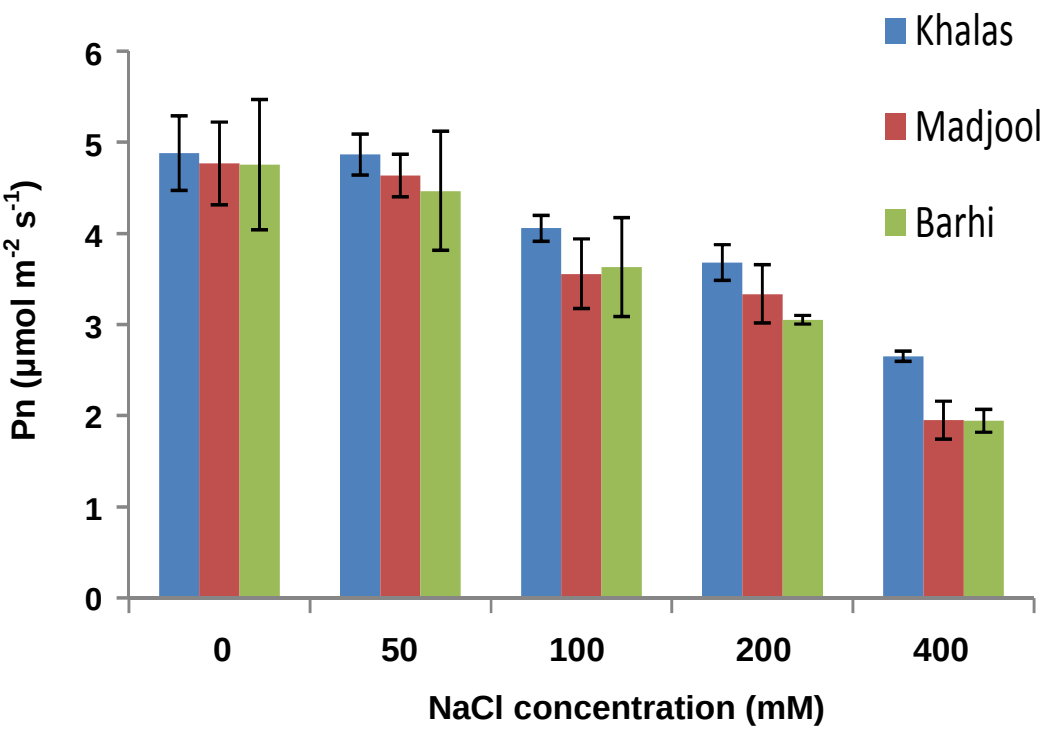

Figure 1. Effect of NaCl on net photosynthesis date palm.

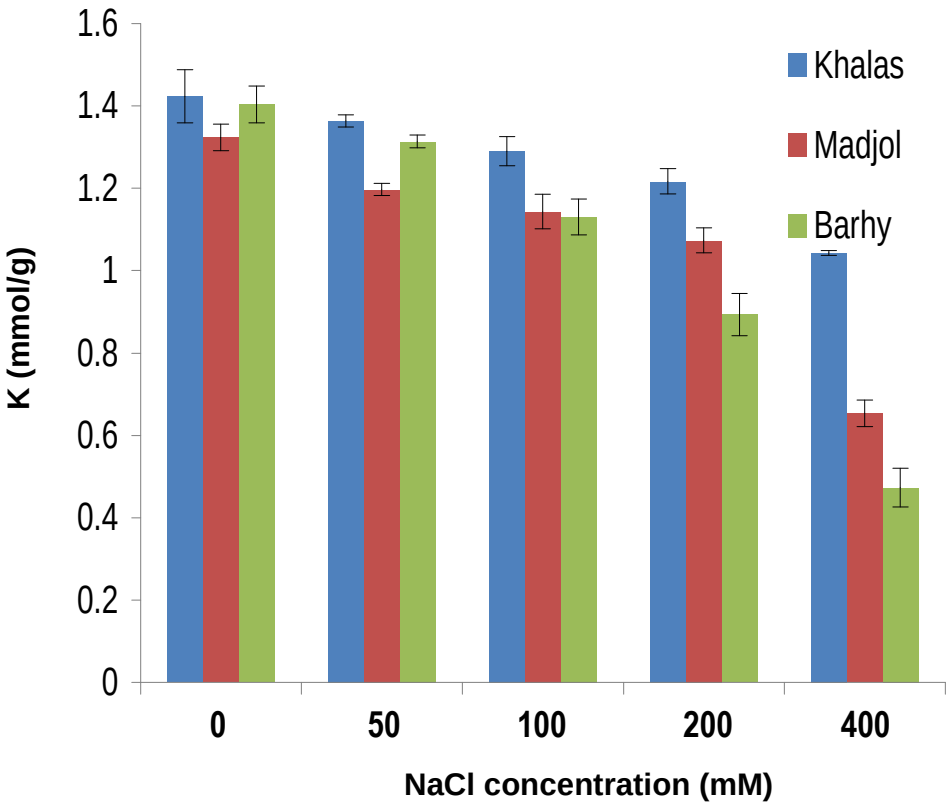

Figure 2. Effect of NaCl on K content in mature date palm leaves.

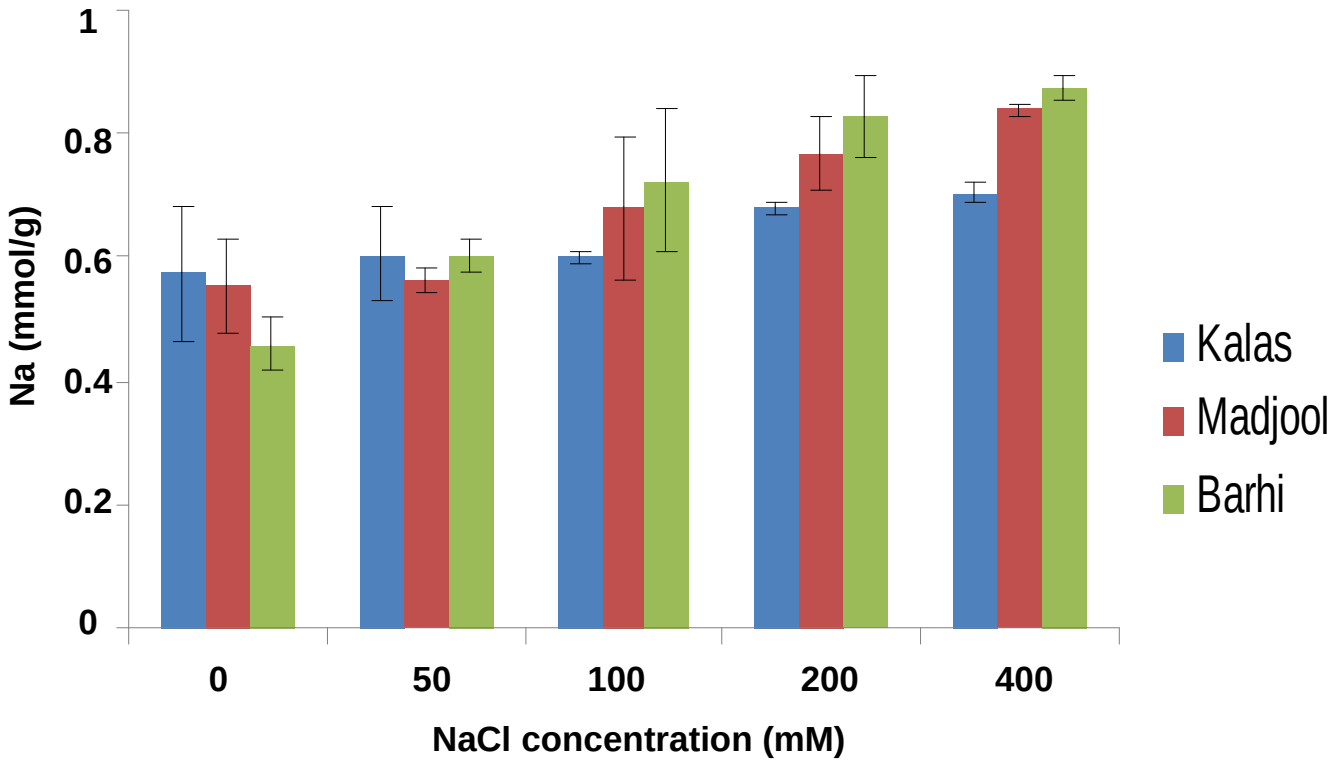

Figure 3. Effect of NaCl on Na content in mature date palm leaves.

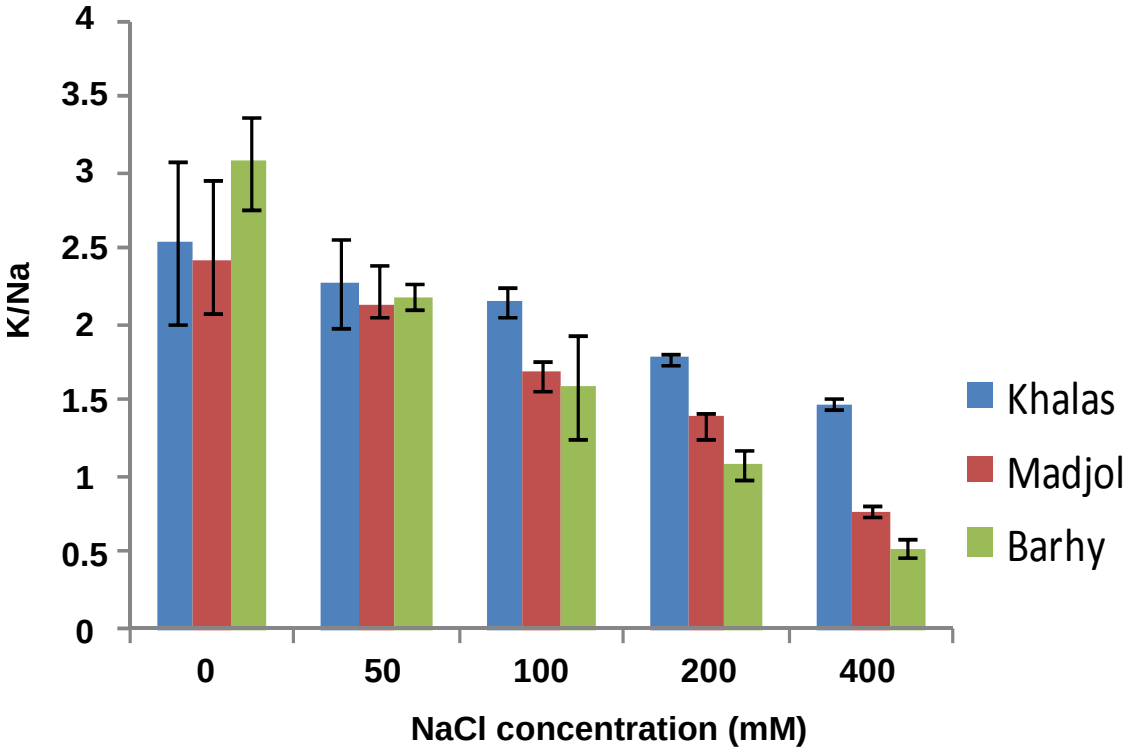

Figure 4. Effect of NaCl on K/Na Ratio in mature date palm leaves.

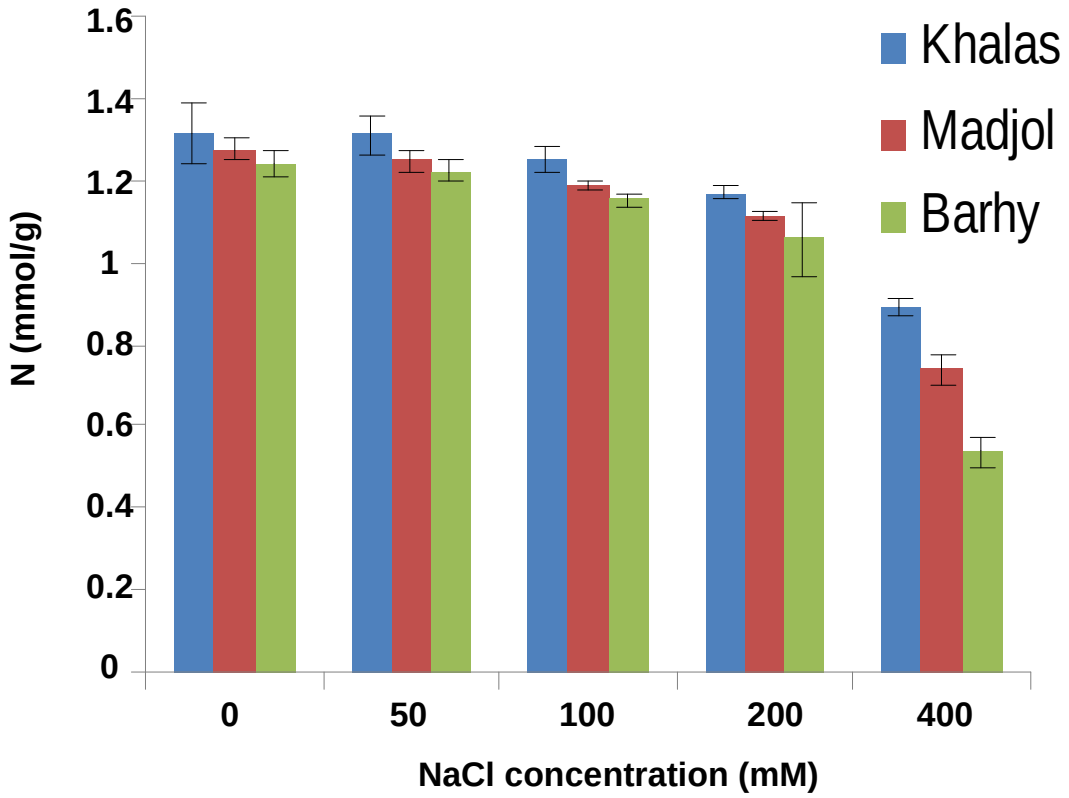

Figure 5. Effect of NaCl on N content in mature date palm leaves.

Table 1. Salinity effects on chlorophyll a (Chl a), chlorophyll b (Chl b) and total chlorophyll (Chl a + b) contents in Date palm leaves.

Salinity (mmol/l)	Variety	Chl a	Chl b	Chl a + b
		mg/g DW		
0	Khalas	1.66 ± 0.04 a	0.74 ± 0.011 a	2.40 ± 0.030 a
	Madjool	1.67 ± 0.743 a	0.73 ± 0.025 a	2.40 ± 0.020 a
	Barhy	1.69 ± 0.03 a	0.74 ± 0.017 a	2.43 ± 0.017 a
50	Khalas	1.62 ± 0.025 a	0.72 ± 0.025 a	2.35 ± 0.043 a
	Madjool	1.62 ± 0.032 a	0.74 ± 0.01 a	2.36 ± 0.025 a
	Barhy	1.62 ± 0.017 a	0.72 ± 0.015 a	2.34 ± 0.032 a
100	Khalas	1.56 ± 0.015 a	0.62 ± 0.011 b	2.19 ± 0.01 b
	Madjool	1.47 ± 0.051 b	0.56 ± 0.01 c	2.03 ± 0.041 c
	Barhy	1.44 ± 0.055 b	0.45 ± 0.036 d	1.89 ± 0.035 d
200	Khalas	1.44 ± 0.01 b	0.41 ± 0.020 d	1.85 ± 0.025 d
	Madjool	1.32 ± 0.025 c	0.32 ± 0.025 e	1.65 ± 0.046 e
	Barhy	1.20 ± 0.015 d	0.27 ± 0.043 e	1.47 ± 0.050 f
400	Khalas	1.12 ± 0.02 e	0.14 ± 0.035 f	1.26 ± 0.015 g
	Madjool	0.76 ± 0.057 f	0.06 ± 0.015 g	0.83 ± 0.043 h
	Barhy	0.43 ± 0.152 g	0.02 ± 0.005 h	0.45 ± 0.148 i

Values are means of five replicates ± SE. Different letters in the same column are significantly different at P <0.05 level, as determined by Dunken.

the atmosphere and produce organic compounds like carbohydrates, proteins and fats. Increasing salinity levels decreased photosynthesis and chlorophyll levels in test cultivars. It can be inferred that CO_2 assimilation was least affected due to salinity in the cultivar Khalas which recorded the best photosynthetic activity.

Our study has shown that Saudi Arabia's premier date cultivar 'Khalas' is able to withstand increasing salinity levels as compared to Madjool and Barhy.

The increasing popularity of Khalas among date palm farmers in the Kingdom can be attributed to its tolerance to increased salinity levels besides having several quality traits including fruit length and preferred texture parameters *viz,* hardness, springiness, cohesiveness and resilience.

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